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- II. "On the Amyloid Substance of the Liver, and its ultimate destination in the Animal Economy." By ROBERT M'DONNELL, M.D. Communicated by WILLIAM BOWMAN, Esq. Received February 13, 1863.

(Abstract.)

After briefly referring to the discovery of the amyloid substance of the liver, and the earlier history of the subject, the author examines the facts which have induced Dr. Pavy to conclude that this substance is not normally transformed into sugar during life. The author being led, after a careful repetition of Dr. Pavy's experiments, to concur in his views, asks, If then the amyloid substance of the liver be not converted into sugar, what becomes of it? what is its normal destination in the animal economy? It is the object of the memoir to attempt to answer this question, which, it must be admitted, is one of the greatest delicacy; nevertheless there appears on the whole to be evidence that the amyloid substance met with in the liver is on its way upwards towards the more exalted or complex immediate animal principles; that, in fact, the process of healthy assimilation tends, if the expression may be used, to promote it from the rank of ternary (hydrocarbonous) to that of quaternary (azotized) compounds; and that its conversion into sugar is to be looked upon as a deviation from this progressive course—a dissimilative instead of an assimilative process. In order to establish this view it became necessary—

1st. To investigate the chemical and physiological relations of the amyloid substance, not only of the liver, but of other organs and tissues, and to test the very interesting results, which are for the most part due to M. Charles Rouget.

2ndly. To compare the portal and hepatic blood with each other, and with arterial and venous blood derived from other sources; and

3rdly. To consider the relations to each other of the different functions performed by the liver. For if it be true, as Lehmann, Brown-Séquard, and others have asserted, that the fibrine and much of the albumen of the portal blood vanishes in the liver, and that at the same time that it destroys these azotized compounds it forms its non-azotized amyloid substance, and excretes bile containing so little nitrogen that it need hardly be taken into account, are we

not, from the consideration of these functions, led to infer that the nitrogen which leaves the liver by no other outlet may go forth in the hepatic blood in union with the amyloid substance thus changed into a new azotized principle;—that thus the liver is a great blood-making organ, in which there is constantly going on a reconstruction of certain ingredients of the blood; that in it the fibrine, &c., which has done its work, is disintegrated, the hydrocarbons of the bile abstracted, and the nitrogen combined with the amyloid substance, which, instead of being normally changed into sugar, emerges from the liver a constituent principle of the protoplasma, from the bosom of which (to use the words of Bernard with reference to the foetal tissues) organic evolution is to be accomplished?

Of the existence of the Amyloid Substance of Bernard in the Placenta and other Organs and Tissues.

The cells of the placenta contain, during the earlier stages of embryonic life, animal dextrine, having characters identical with those of the amyloid substance of the liver; its presence may be readily demonstrated under the microscope. Bernard has discovered it in the placentæ of rabbits, guinea-pigs, &c. He also made the very interesting observation that the multiple placentalæ of the ruminants do not contain any amyloid substance, but that in this class of animals this substance is found in certain cells of the amnion. The presence, however, in the amnion or the placenta, of epithelial cells containing amyloid substance, is a fact quite secondary to the general fact that this substance enters largely into the constitution of most of the tissues of the embryo. Its existence does not indicate a new function of an organ doing temporarily the duty of the liver, but it indicates a new fact with regard to the development of certain structures and a new property of tissue. During embryonic life a great part of the foetal tissues are found to be so impregnated with amyloid substance, that it appears to be the formative material from which these tissues are evolved; and, in fact, it would seem to be related to their growth and development, as starch is to the growth and development of the tissues of vegetables. In the skin of the chick *in ovo*, and of the foetuses of rabbits, cats, guinea-pigs, sheep, oxen, pigs, it is readily demonstrated; it is seen by the addition of acidulated tincture of iodine,

and is most abundant at the points where the aggregation of epithelial cells shows that the feathers and hairs are about being developed. The horny structures contain it plentifully; in the bill, the hoof, and the claws it exists in large proportion. From the hoof of a foetal calf of about four months enough may be obtained, by the alcoholic solution of potash, for chemical examination and fermentation. The muscular tissues of the foetus are full of it; from 20 to 50 per cent. can be extracted from the muscles of foetal calves of from three to seven months by the aid of the alcoholic solution of potash.

Having arrived, by a repetition of Dr. Pavy's ingenious experiments, at the conclusion that the amyloid substance of the liver is not normally changed into glucose, and finding on examination the accuracy of the facts concerning the physiological relations of the amyloid substance to the foetal and other tissues, discovered by M. Charles Rouget, and investigated by Bernard himself, the question presents itself, May it not be that the liver does for the adult what divers tissues do during the development of the foetus? May not this great organ form, with the help of the amyloid substance secreted in its cells, a nitrogenous compound, just as the muscles of the foetus convert the amyloid substance contained in them into the highly nitrogenous material of muscular tissue?

May not, in fact, the amyloid substance of the liver be the basis of an azotized protoplasma forming a constituent of the blood of the adult animal, as the amyloid substance of muscle is the basis of the material from which the evolution of muscular tissue is accomplished?

Even a superficial consideration of the functions performed by the liver leads one to answer these questions in the affirmative. For if it be true that the blood which enters the liver is rich in fibrine and albumen, and that these materials are so completely changed within this organ that little or none of them leave it by the hepatic vessels, what becomes of them? It is true their hydrocarbonous constituents may be thrown out as bile. But what of the nitrogen contained in them? If it does not escape by the bile-ducts, it has no other mode of exit save by the hepatic vessels. The author conceives it to be reunited with the hydrocarbonous amyloid substance, and to leave the liver as a newly-formed proteic compound, partly perhaps as

globuline, and partly as material, in its reactions resembling caseine in some respects, in others albuminose, and which is fully described in the memoir. These considerations lead to the necessity of investigating the several distinct functions of the liver :—

1st. As to its action on the fibrine and albumen of the blood.

2nd. As to the constitution of healthy bile (so far as its azotized elements are concerned).

3rd. As to the relative composition and characters of the blood which enters and of that which leaves the liver.

The author adds his testimony to that of Lehmann and Brown-Séquard as regards the fibrine-destroying function of the liver ; he attempts to show that, in proportion to the amount of fibrine which disappears in the liver, the quantity of nitrogen eliminated in the form of bile is very small indeed, but that the blood in passing through the liver becomes greatly enriched in colourless corpuscles, and that it contains more abundantly than other blood an azotized compound, resembling what has been described by some authors as blood-caseine. This material, although resembling, is not identical with caseine ; it can be obtained from the serum of blood abstracted by a peculiarly contrived instrument (a drawing of which accompanies the paper) from the vena cava, close to the mouths of the hepatic veins.

Whatever may be its precise chemical composition and characteristics, whether it is to be regarded as a form of albumen, or albumen-peptone (albuminose), or caseine, it is enough to state, that during active digestion the blood which leaves the liver contains a proteic compound, that it is richer in this compound than arterial blood, and that this latter is richer in it than ordinary venous blood, or than that of the portal vein. At the same time the blood of the hepatic veins contains a far larger quantity of colourless blood-corpuscles than the portal blood.

A microscopic examination of these kinds of blood shows that the colourless corpuscles are from five to ten times more numerous in the former than in the latter. Physiologists are so familiar with this fact, as well as with the chief peculiarities of the colourless corpuscles of hepatic blood, that it is unnecessary to dwell upon the circumstances which have induced some of the most distinguished among them to regard as the most important function of the liver, the

formation, or at least the rejuvenescence, of the blood-corpuscles. Dr. Carpenter conceives that the appearance of the colourless corpuscles of the blood may be regarded as a phenomenon analogous to the development of cells in the albumen of seeds in the vegetable kingdom. He also supposes that these cells aid in the conversion of crude alimentary matters into proximate principles. Additional support is given to each supposition by the notion that these colourless cells stand in close relationship to the material formed in the liver, so closely resembling dextrine of vegetable origin.

It is true that there is nothing novel in the view that the liver is a great blood-forming organ, or rather that it is an organ in which certain components of the blood are disintegrated, while from some of the matter so disintegrated a constant reconstruction of the blood is going forward; yet it is certain that, not long since, physiologists would have been unwilling to admit that materials constituted as the colourless blood-cells or caseine could be formed within the liver from a substance resembling starch taking to itself nitrogen derived, as one may say, from the retrogressive metamorphosis of tissue. It is very improbable that, looking to the liver alone, such a conclusion would have been arrived at. The consideration, however, of the physiological relations of the amyloid substance (of Bernard), as regards the development of the azotized tissues of the fœtus,—the fact that it is, so far as they are concerned, a protoplasma, which, by taking to itself nitrogen, terminates in the evolution of fully-formed nitrogenous tissues,—prepares one to consider the idea that the liver evolves its proteic compounds during adult life by a somewhat similar process.

To M. Charles Rouget we unquestionably owe the observation of the fundamental facts which lead to the foregoing conclusions; yet the author hopes that the recapitulation of facts in this communication will be found worthy of the consideration of physiologists; for he conceives that not only is the view of the subject which he has ventured to adopt in harmony with a great number of hitherto unexplained circumstances, but that it gives a solution more satisfactory than any yet given of certain pathological phenomena which it would be out of place to speak of here.